VOLUME XXVI NUMBER 5

BOTANICAL GAZETTE

NOVEMBER 1898

THE COMPARATIVE MORPHOLOGY OF THE PISTILS OF THE RANUNCULACEÆ, ALISMACEÆ, AND ROSACEÆ.[1]

ERNST A. BESSEY.

(WITH PLATE XXV)

RANUNCULACEÆ.

THERE are two types of pistil present in this family. In the first there is but a single ovule in each pistil; in a specialized form of this type there are, besides the one principal ovule, two to six rudimentary ovules subsequently developed, but never reaching maturity. The second type consists of those pistils which have two to many ovules, all or nearly all reaching maturity. Pistils of the first type are found in the Ranunculeæ, Anemoneæ, and Clematideæ, and of the second type in the Helleboreæ and Paeonieæ.

The species studied to determine the mode of development of the pistils were the following: *Ranunculus abortivus* L., *R. eremogenes* Greene, *R. delphinifolius* Torr., *R. ovalis* Raf., *R. glaberrimus?* Hook., and *Myosurus minimus* L., all representing the strictly uniovulate type; and *Anemone Caroliniana* Walt., *A. cylindrica* Gray, *A. Canadensis* L., *Pulsatilla hirsutissima* (Pursh) Britt., and *Clematis ligusticifolia* Nutt., representing the uniovulate type where rudimentary ovules are developed. For the study

[1] A thesis for the degree of Master of Arts, in The University of Nebraska, 1898.

of the multiovulate type, use was made of *Delphinium Carolinianum* Walt., and *Caltha leptosepala* DC.

RANUNCULUS ABORTIVUS. The pistil first makes its appearance as a slight rounded projection from the surface of the then small receptacle. This projection enlarges, as does the receptacle, until it is almost hemispherical. It then begins to elongate, and during this process a second, rounded projection appears in the axil of this as yet only slightly developed carpellary leaf (*fig. 1*). The second rounded mass of cells is produced as a result of the rapid division of the hypodermal cells, and is not epidermal, but is covered with epidermis. At this time a cross-section of the pistil shows that the upper side is slightly flattened. This flattening becomes more pronounced until, in a short time, the pistil is seen to be slightly concave above, *i. e.*, the edges of the carpellary leaf are beginning to fold around, eventually to meet to form a closed pistil (*fig. 2*).

In addition to this lateral folding, the outer part of the pistil soon begins to bend upward, until its apex, which was at first directed at right angles to the surface of the receptacle, now points in a direction parallel to it. The lateral folding, also, continues, nearly closing the upper part of the pistil (*figs. 3, 4*). In the meantime the axillary mass of cells has been growing, especially at the side towards the receptacle, causing its apex to turn away from the receptacle and down into the cavity in the upper part of the pistil, which has been bending upward, and towards the receptacle. It has now become possible to distinguish two parts in the axillary mass of cells; a thicker basal part (which I will call the "axillary placenta," since it arises in the axil of the carpellary leaf) and a slender apical part, the ovule, which bends down between the laminae and thus into the hollow of the pistil (*figs. 5, 6*). The axillary placenta itself is really not within the pistil, but forms part of the wall on the ventral side. The laminae of the pistil extend to it and are continuous with its outer layers of cells, and extend from it to the apex of the carpellary leaf, which has bent around almost in a semicircle. When these laminae finally come together to close the pistil, they curve in over the top of the axillary placenta, forming a forked suture shaped like an inverted letter Y.

While the carpel has thus been curving upward, the growing nucellus has been bending downward, the former describing an arc of 180°, while the latter passes through only 120°. A short time before this stage is reached the archesporial cell is differentiated, the exact time being very variable. The wall of the pistil furthest from the receptacle now elongates considerably, with the result that the longest axis of the pistil instead of being, as at first, at right angles to the surface of the receptacle, is now parallel to it. The ovule still continues to bend until it, too, lies in the main axis of the pistil, but with the micropyle pointing down. The last small opening of the pistil is now closed by the meeting of the edges of the laminae. It is the line of meeting of the laminae with the upper side of the axillary placenta, or in other words, one of the arms of the inverted Y-shaped suture, that shows so distinctly in all median or almost median sections of the pistil (*fig. 8, a*).

The main fibrovascular bundle supplying the pistil divides just after entering it. One branch passes around in the median line in a position corresponding to the bundle of the mid-rib of a leaf. The other passes up into the axillary placenta, through the funiculus and into the base of the nucellus, also in the median line (*fig. 8*). Later other branches run to the side walls of the pistil.

Ranunculus eremogenes. The development of the pistil in this species is almost identical with that in *R. abortivus.* The pistil begins as a rounded outgrowth from the receptacle (*fig. 9, a*), which is more developed in this species at this stage, than in the preceding. Immediately above the base of this outgrowth there arises another, eventually to become the ovule. This is shown in *fig. 9*, at *b*, which is a rudimentary pistil, with the still more rudimentary ovule three or four cells higher. The pistil flattens dorsiventrally and the edges begin to fold together, while the apex also curves upward. The axillary papilla at the same time elongates and the distinction of ovule and placenta is made. The ovule bends down into the space between the laminae of the carpel. The single integument now begins to make its appearance, and the archesporium becomes visible as a specialized cell. By this time the ovule has described an arc of 120° from the position held by the axillary papilla when it first appeared. The development is now so rapid that by the time the archesporium has divided into two cells and each is beginning to divide again, the ovule has bent 30° more (*fig. 10*), and at the completion of the division has bent another 30°. At the same time the apex of the carpel has passed through an arc of 180°, and the main axis of the pistil has become parallel to that of the receptacle. A noteworthy fact in connection with the development of the archesporium is that the two megaspores nearest to the micropyle lie in a line nearly at right angles to the main axis of the nucellus (*fig. 10*). Soon after this stage is reached the pistil becomes closed through the meeting of the edges of the laminae. A front view of a nearly mature pistil shows that in this species, as in *R. abortivus*, the suture is shaped like an inverted Y (*fig. 19*).

Ranunculus ovalis, R., *glaberrimus ?* and R. *delphinifolius* show in their later stages the same structure as described above, indicating that they probably have a similar course of development.

MYOSURUS MINIMUS. This species has a long, narrow receptacle, in strong contrast to the short hemispherical one of Ranunculus. On it is shown more vividly what is apparent to a slight degree on the receptacle of Ranunculus, viz., the acropetal development of the pistils. In Ranunculus the difference in age of the pistils on the different parts of the receptacle is only slight, and soon disappears. On the other hand, in Myosurus, even when the pistils on the lower part of the receptacle are well developed, others are just appearing at the top. As in the preceding genus, the pistil appears as a slight papilla on the surface of the receptacle. As it elongates, its apex is directed slightly downwards. On the upper side of the pistil, next to the receptacle, is then developed an axillary papilla whose axis, at first, forms an angle of about 35° with the surface of the receptacle, while the apex of the pistil is directed so as to form an angle of about 90° with the axis of this papilla (*fig. 11*). Even at this stage the outer part of the pistil is flattened above (*figs. 12, 13*). This flattening progresses until a longitudinal groove is formed in the upper surface of the carpellary leaf, extending back to the axillary placenta. The apex of the carpel now begins to bend upward, while the ovule begins to grow downward. By the time that the ovule has bent 45° from its original position, the archesporium appears. The outer part of the pistil has also changed its direction by 45°, thus bringing the ovule partly within the cavity formed by the laminae which connect the axillary placenta with the apex of the carpel (*fig. 14*). At the time that the first traces of the single integument appear, the archesporium has divided into two cells and the ovule points directly down, *i. e.*, in its curving it has described an arc of about 145°. The apex of the carpel has in the same time described an arc of only 125°, so that it lies parallel to the receptacle (*fig. 15*). For some time further the pistil does not change much except in size. The ovule, on the other hand, is active in its changes. By the time that the megaspore furthest from the micropyle has by its enlargement destroyed the others (two or three in number), the ovule has curved 90° more (*figs. 16, 17*). This process continues until at the time that the embryo sac is ready for fertilization the ovule lies with its axis parallel to that of the receptacle, a change in direction of about 325° (*fig. 18*). To accommodate the ovule thus bent upon itself the lower part of the pistil elongates somewhat, so that the fibrovascular bundle of the median line of the carpel, after leaving the receptacle and giving its branch to the ovule, passes first downward, then outward, and finally upward. The bundle going to the ovule passes first upward, then outward, then downward, and finally inward to the base of the nucellus. From this time on until the seeds drop, the position of the nucellus remains the same, so that by making longitudinal sections of the flower, it is easy to obtain longitudinal median sections of all the ovules, from one hundred to two hundred in number. As in Ranunculus, the pistils are not entirely closed until a very short time before fertilization, and then in the same manner. The further development of the pistil after fertilization is, however, a little different in the two genera. In Myosurus, instead of enlarging rapidly so as to leave a large cavity which the ovule fills only in part, the pistil enlarges only as does the ovule, leaving no cavity. The walls, too, do not become stony, thus allowing (what is very difficult in Ranunculus) the study of the development of the embryo.

ANEMONE. In the first stages of the development of the pistils this genus resembles Myosurus very closely. In fact, the development throughout of the single large ovule is as in that genus (*figs. 20–23, 26*). A slight difference in the shape of the pistil is noticeable, in that the cavity is prolonged somewhat above the ovule. In *Anemone Caroliniana*, after the ovule has curved down into the cavity of the pistil, there appear on the edges of the laminae, which are now closing together, two projections. These increase in size, growing down into the cavity of the pistil above the first ovule. They remain merely few-celled papillae in this species, one on each lamina, the central cells resembling archesporial cells (*fig. 24*). This occurs also in other species of this genus, the papillae in some species often becoming well-marked, rudimentary ovules. This is so common that Baillon describes[2] Anemone as being provided with five ovules, four being aborted and one descending and fertile.

CLEMATIS LIGUSTICIFOLIA. The pistils in this species are even more elongated than in Anemone, and have the cavity correspondingly elongated above the ovule. Unfortunately, it was impossible to obtain the younger stages, but the close agreement of the older stages with those found in Anemone makes it practically certain that the course of development is the same. The mature ovule is situated exactly as in Myosurus and Anemone. Like the latter, however, on each side above the large ovule the lamina bears one or two rudimentary ovules which project into the space above it (*fig. 25*). The only dif-

[2] BAILLON: Mémoire sur la famille des Renonculacées. Adansonia 4:50. 1864.

ference between this and *Anemone Caroliniana* is that the ovules are further developed, some of them in fact having embryo sacs with two or four nuclei. Guignard describes[3] and figures these accessory ovules in *Clematis cirrhosa* with embryo sacs containing two and four nuclei, showing conclusively their ovular nature. Some species of Anemone, too, have these accessory ovules developed to this extent, showing that in this there is no distinction between the two genera.

DELPHINIUM CAROLINIANUM. Owing to the ease with which the material could be obtained, this species was the one chiefly used in the study of the multiovulate type of pistil. *Caltha leptosepala* was used to corroborate the results obtained from the study of this species. It was evident from figures and descriptions of the pistils of this type, published elsewhere, that these two species give us typical examples, and it was accordingly decided that it would be unnecessary to make careful study of other species. Unfortunately it was impossible to obtain specimens of those genera with biovulate pistils, forming perhaps the transition from the uniovulate to the multiovulate genera. The pistils arise at the top of the nearly hemispherical receptacle. The stamens develop acropetally. The pistils do not show any signs of appearing until all the stamens have begun to develop. Each pistil first appears as a small conical papilla with rounded apex, and increases in size very rapidly. As this increase in size progresses, the ventral side begins to be hollowed out, until by the time that the pistil is a millimeter in height, and a little narrower than high, it has become closed by the meeting of the laminae (*figs. 27, 28*). Soon the ovules begin to make their appearance as small papillae on the inturned edges of the carpellary leaf. These increase rapidly in number and size until the edges of the laminae of the pistil are occupied entirely by horizontally growing ovules (*fig. 29*). In Delphinium the ovules arise opposite to each other, but later, owing to the crowding due to their growth in size, they become alter-

[3] GUIGNARD, LEON: Récherches sur le sac embryonnaire des phanérogames angiospermes. Ann. Sci. Nat. Bot. VI. **13**: 163. *pl. 5*. 1882.

nate. The lowest ovule, having no ovule below to sustain it, may descend into the hollow at the bottom of the pistil.

In *Caltha leptosepala* the ovules are mostly alternate, and are fewer in number than in the pistils of Delphinium, the difference being apparently compensated by the greater number of pistils in the former. The only other difference worthy of mention is that the ovules of Caltha are two-coated, while those of Delphinium have only one integument (*fig. 31*).

ALISMACEÆ.

The two genera studied were Sagittaria and Alisma. These are in the main, alike so far as the development of the pistils is cerned, for the slight differences that do occur are easily explicable by the difference in number of the pistils, involving their relations to each other and to the receptacle. Thus in *Alisma Plantago aquatica* L. there is but a single whorl of pistils, while in *Sagittaria latifolia* Willd. the ovules are very numerous and arranged spirally over the whole surface of the receptacle.

SAGITTARIA LATIFOLIA. In this plant, as in Myosurus, the pistils are developed acropetally. Each pistil makes its appearance as a papilla on the side or summit of the spherical receptacle. As this papilla enlarges it grows so as to leave a hollow on the upper side. In its axil there now appears a second papilla, which grows out into the space between the laminae of the pistil, which has now become somewhat curved. As these laminae increase in width they surround the ovule entirely except the very slightly developed "axillary placenta." As a result of this the ovule appears to arise from the floor of the pistil, as indeed some descriptions aver (*figs. 33–35*). While the pistil has been thus developing, the ovule has not remained unchanged. It has increased in length, and about half way from base to apex makes a sudden turn, at which place the two integuments arise. The ovule continues to bend upon the funiculus until by the time that the integuments have reached the apex of the nucellus the latter lies parallel to the surface of the receptacle, with its apex pointed away from the apex of the receptacle (*fig.*

36). Within a very short time the position of the ovule becomes permanent, with the apex of the nucellus directed towards the receptacle (*fig. 37*). Subsequent changes are mostly those in size and such modifications of shape as are caused by the pressure of the surrounding pistils.

ALISMA PLANTAGO AQUATICA. In the very young flowers of this species the receptacle is much broader above than below, and has a rounded top. It is from the narrower basal part that the stamens arise, while the pistils are produced at the edge where the receptacle is widest. They appear as projections, at first small, later larger (*fig. 38*). This gives the receptacle, viewed from above, the appearance of a toothed wheel. The receptacle grows rapidly in height, as do the apex and sides of each pistil, thus forming a hollow in the upper side of each (*fig. 39*). Into this rapidly deepening cavity, there pushes out from the receptacle a rounded mass of cells (*fig. 40*). The apical part of the pistil grows very rapidly until the laminae connecting it with the receptacle at each side of the ovular outgrowth are in such a position that their edges are nearly vertical. The ovule continues to elongate and curve towards the bottom of the pistil, eventually gaining a position in which its apex is directed downwards. During this process the nucellus has become differentiated and the two integuments have appeared. The funiculus has also been clearly distinguished (*figs. 41, 42, 43*). Up to the time of fertilization there has been no organic connection between the edges of the two laminae, although for a little while they have been in contact for a part of their distance. At the time of pollination there is still an opening between the laminae at the bottom of the line of meeting. This is due to the fact that the laminae arise with enough distance between them to allow for the formation of the ovule. Now, when their margins approach each other they are separated furthest at the bottom and require a longer time to come fully together (*fig. 44*). In the mature pistil the funiculus is long and ascending, carrying the ovule well up into the cavity of the pistil. In the young pistil the funiculus is short, and it is only as the pistil grows that the funiculus also increases in length.

ROSACEÆ.

This family contains representatives of many types of flower-structure. Of these types the Potentilleæ have been regarded hitherto as the simplest. In this tribe the pistils are very numerous, on a rounded receptacle, which is expanded below into a shallow cup, on whose edge are borne the numerous free stamens, the petals and the sepals. In Fragaria and Potentilla each pistil is uniovulate, while in Geum it is biovulate. As a rule throughout the family the pistils are biovulate, and in some genera even multiovulate. The only genera studied as representatives of this family were Potentilla and Fragaria, it being the aim to determine whether the remarkable similarity that these show to Ranunculus is also found in the processes of development of the parts of the flower.

POTENTILLA MONSPELIENSIS L. The pistils first appear, as in Ranunculus, as small papillae on the surface of the pistil-bearing part of the receptacle. The first to appear are at the base and the others arise successively towards the top of the receptacle (*fig. 45*). As the pistils enlarge they become hollowed out above. A comparatively small opening is produced on the upper side of the pistil (*fig. 46*), which is made still narrower by the thickening of the edges of the laminae for about half the distance from base to apex. This thickening is sometimes accompanied by a more active growth in width of that part of each lamina, so that viewed from the side it appears as a rounded lobe, as shown in *fig. 47*, where the dotted line shows the more usual form. From one of these thickened edges or lobes a small papilla begins to grow inward and downward, later turning upward again. This is the ovule. It is at first lateral in its position, but the lamina to which it is attached grows more rapidly than the part opposite, so that the ovule finally occupies a median position (*fig. 48*). The ovule, when the pistil is ready for pollination, is anatropous, with the funiculus on the ventral side of the pistil, instead of on the dorsal as in Myosurus. The ovule has but a single integument, and in the large size of its nucellus, as well as in its position in the pistil, much resembles that of Ranunculus (*fig. 50*).

FRAGARIA VIRGINIANA. The development of the pistil in this species is practically identical with that in the preceding. The only important difference is that the line in which the laminae meet is shorter, so that the style arises from well down on the front of the pistil. In this species is also found what probably indicates an advance in development beyond that shown in Potentilla, namely, quite often a pistil contains two ovules instead of one. This doubling is acomplished by the formation of one ovule on each of the thickened laminae, instead of on one only. Possibly this is the way in which the uniovulate genera, like Potentilla, have developed into the typical biovulate genera of the family (*figs. 51–53*).

GENERAL DISCUSSION.

A comparison of the structures exhibited by the pistil in these three families shows that each family includes genera with uniovulate as well as those with multiovulate pistils, and that the course of development of the uniovulate pistils is very similar in the three families, although in Potentilla and Fragaria it has been somewhat modified.

It has been shown above that in Ranunculus the first sign of the ovule is the growth of a mass of cells in the axil of the developing carpel. The carpel elongates and becomes hollowed above by the upward growth of the laminae, which do not grow up over the axillary mass of cells, but rather extend from it on each side to the apex of the carpel. By the elongation of the distal part of the axillary body the ovule is formed, and curves down into the cavity of the pistil, while the proximal part remains in its original position, growing only in height and thickness. The laminae which extend from this body (called above the "axillary placenta") to the apex of the carpel, now approach each other at their edges, and meet in the median line, thus completely closing the cavity of the pistil. The suture along which the laminae meet is like an inverted Y, for before they close they are separated at the bottom by the axillary placenta (see *fig. 19, R. eremogenes*).

If we now compare with this the conditions found in Potentilla and Fragaria, we see the following modifications. There is no axillary mass of cells developed, for the ovules have their origin on the edge of one or the other lamina. Probably this originated as follows: in some plant whose ovules were borne as in Ranunculus, and in which the suture along which the laminae met formed an inverted Y, a variation appeared by which the axillary placenta lost its median position, one arm of the suture becoming elongated and the other shortened. This resulted in a placenta attached to one lamina and free from the other, which is precisely what we find in Potentilla. Even in Ranunculus it occasionally occurs that the axillary placenta is not strictly median but slightly shifted to one side or the other. This suggests that the mode of origin indicated above is not improbable.

In the uniovulate pistils of Fragaria as well as of Potentilla the ovule is borne sometimes on one lamina and sometimes on the other, being very variable in this respect. Under such conditions when neither lamina is especially modified for the production of ovules it is probable that sometimes an ovule might be borne on each lamina, as happens in Fragaria. It seems probable that it was by such a variation that the majority of the genera of the Rosaceæ became biovulate. When once each lamina began to be ovuliferous it would be but a short step to the condition in which several ovules are borne, instead of only one. In this way the multiovulate pistils may have arisen. Probably in this way, too, the multiovulate Ranunculaceæ were developed from the uniovulate Ranunculus, possibly through a biovulate form close to Callianthemum, or even Hydrastis.

From the description of their development as given above it must be evident that Sagittaria and Alisma are quite similar to Ranunculus. Of these two genera, however, Alisma is much less like Ranunculus than is Sagittaria, for the ovule is hardly axillary with respect to the carpel, but arises from the receptacle, in this respect much resembling the origin of the sporangium of Selaginella. The condition found in Sagittaria is one about midway between that in Alisma and that in Ranunculus. In the latter the axillary placenta is in reality only an outgrowth from the receptacle, and this prepares us to find (as in the Alismaceæ) the ovule developed directly from the receptacle. In other cases, as in Potentilla, this axillary placenta loses its individuality by fusion with one of the laminæ of the carpel.

The presence of the accessory ovules in Anemone, Pulsatilla, Clematis, and other genera is difficult to explain. If it were not for the peculiar origin of the one ovule which reaches maturity, it might naturally be supposed that Anemone is descended from plants with multiovulate pistils. However, if this were the case it would be necessary to consider also that Ranunculus and Myosurus had a similar origin, which seems highly improbable in consideration of their close resemblance to the Alismaceæ, which show in other characters no signs of having had Anemone-like ancestors. Furthermore, there are no existing multiovulate Ranunculaceæ that seem to be as simple in other respects as Ranunculus, for their pistils are fewer in number and close much earlier, an evident unsimilarity to the theoretical pteridophytic ancestors of the angiosperms. Perhaps the best solution of the problem is the supposition that some plant of the Ranunculus or Myosurus type after the development of its first ovule varied so as to develop in the space above the ovule one or more accessory ovules which were unable to reach maturity. These accessory ovules being in the unoccupied upper part of the pistil out of the way of the large ovule, and yet protected by the carpel wall, would have no part in the struggle of the plant for existence, and so might persist. This would be the more likely to be true if this modification happened to occur in a plant which, owing to other modifications, was enabled to maintain itself against all enemies, and to be well distributed. This seems to have been the case here, for these accessory ovules are found in those genera in which the ripe achenes are furnished with hairs to aid in their distribution. Evidently under such circumstances, where they occupy a neutral position they would persist although not yet functional.

The uniovulate types might be summed up as follows. These all represent a type of pistil in which an axillary structure appears, developing directly into the ovule in some cases, or in others forming an axillary placenta on which the ovule is borne, or in still others uniting with one lamina of the pistil and bearing at its summit an ovule.

The multiovulate types are not sufficiently different to require discussion beyond the statement that they are probably developed from a modification of the last mentioned case among the uniovulate pistils.

THE UNIVERSITY OF NEBRASKA,
Lincoln, Nebr.

EXPLANATION OF PLATE XXV.

NOTE.— All the figures were drawn by the author, by means of the camera lucida, with one or two exceptions, from sections 7 to 18μ in thickness, cut upon a Reinhold-Giltay microtome. Some of the material was fixed with 1 per cent. chromic acid solution, some in various platinic chloride mixtures, and the remainder in various osmic acid mixtures, imbedded in paraffin, sectioned, and mounted in Canada balsam. All sections were stained on the slide, many different stains being used. The sections were examined by means of Reichert's objective 8, and oculars 2 and 4. In making the drawings only the outer layer of cells or merely the outline is given.

When not otherwise stated all sections called "longitudinal" are median longitudinal sections.

The magnifications given are those of the drawings, which were reduced one-half in engraving.

Ranunculus abortivus L.

FIG. 1. Longitudinal section of a very young pistil. × 565.

FIG. 2. Cross section of a slightly older pistil. × 565.

FIG. 3. Longitudinal section of a pistil showing the axillary mass of cells. × 565.

FIG. 4. Cross section of a pistil from the same flower as *fig. 3*, in the line *a–a*. × 565.

FIG. 5. Longitudinal section of a pistil at the time of formation of the archesporium. × 565.

FIG. 6. Cross section of a pistil in the same flower as *fig. 5*, in the line *b–b*. × 565.

FIG. 7. Longitudinal section of a pistil at the time of formation of the four megaspores. × 224.

FIG. 8. Longitudinal section of fully developed pistil. × 250.

Ranunculus eremogenes Greene.

FIG. 9. Longitudinal section of two very young pistils. × 565.

FIG. 10. Longitudinal section of the ovule during the formation of the four megaspores. × 565.

Myosurus minimus L.

FIG. 11. Longitudinal section of a very young pistil. × 565.

FIG. 12. Cross section of apical part of a pistil from the same flower as *fig. 11*. × 565.

FIG. 13. Cross section of the basal part of a pistil from the same flower. × 565.

FIG. 14. Longitudinal section of a pistil at the time of the appearance of the archesporium. × 565.

FIG. 15. Longitudinal section of a pistil at a later stage than in the preceding figure. × 265.

FIG. 16. Longitudinal section of a pistil approaching maturity, but with the embryo-sac not far developed as yet. × 250.

FIG. 17. Longitudinal section of a pistil a little older. × 205.

FIG. 18. Longitudinal section of a mature pistil. × 125.

Ranunculus eremogenes Greene.

FIG. 19. Longitudinal ventral section of a pistil showing the formation of the suture shaped like an inverted Y. × 250.

Anemone cylindrica Gray.

FIG. 20. Longitudinal section of a young pistil, showing the beginning of the formation of the axillary body. × 540.

FIG. 21. Longitudinal section of the pistil at the time of the formation of the archesporium. × 535.

Anemone Caroliniana Walt.

FIG. 22. Longitudinal section of a pistil at the time of formation of the archesporium. × 250.

FIG. 23. Longitudinal section of a pistil with the embryo sac developed about halfway. × 120.

FIG. 24. Section of a pistil from the same flower as the preceding, in the line *c–c*. × 122.

Clematis ligusticifolia Nutt.

FIG. 25. Longitudinal section of a mature pistil, showing the accessory ovules. × 75.

Anemone Caroliniana Walt.

FIG. 26. Longitudinal ventral section showing the formation of the inverted Y-shaped suture. × 120.

Delphinium Carolinianum Walt..

FIG. 27. Longitudinal ventral section of a pistil before the appearance of the ovules. × 125.

FIG. 28. Cross section, in the line *d–d,* of a slightly older pistil, but with as yet no ovules. × 125.

FIG. 29. Cross section of a pistil showing ovules. × 75.

FIG. 30. Longitudinal ventral section of a pistil. × 75.

Caltha leptosepala DC.

FIG. 31. Cross section of a pistil ready for pollination. × 75.

Sagittaria latifolia Willd.

FIG. 32. Longitudinal section of an ovule with two archesporial cells. × 520.

FIG. 33. Longitudinal section of a pistil showing a single archesporial cell. × 540.

FIG. 34. Cross section of a pistil in the line *e–e* of *fig. 33*. × 525.

FIG. 35. Longitudinal section of a pistil a little further developed than the preceding. × 410.

FIG. 36. Longitudinal section of a pistil with an embryo sac containing two nuclei. × 155.

FIG. 37. Longitudinal section of a pistil ready for pollination. × 75.

Alisma Plantago aquatica L.

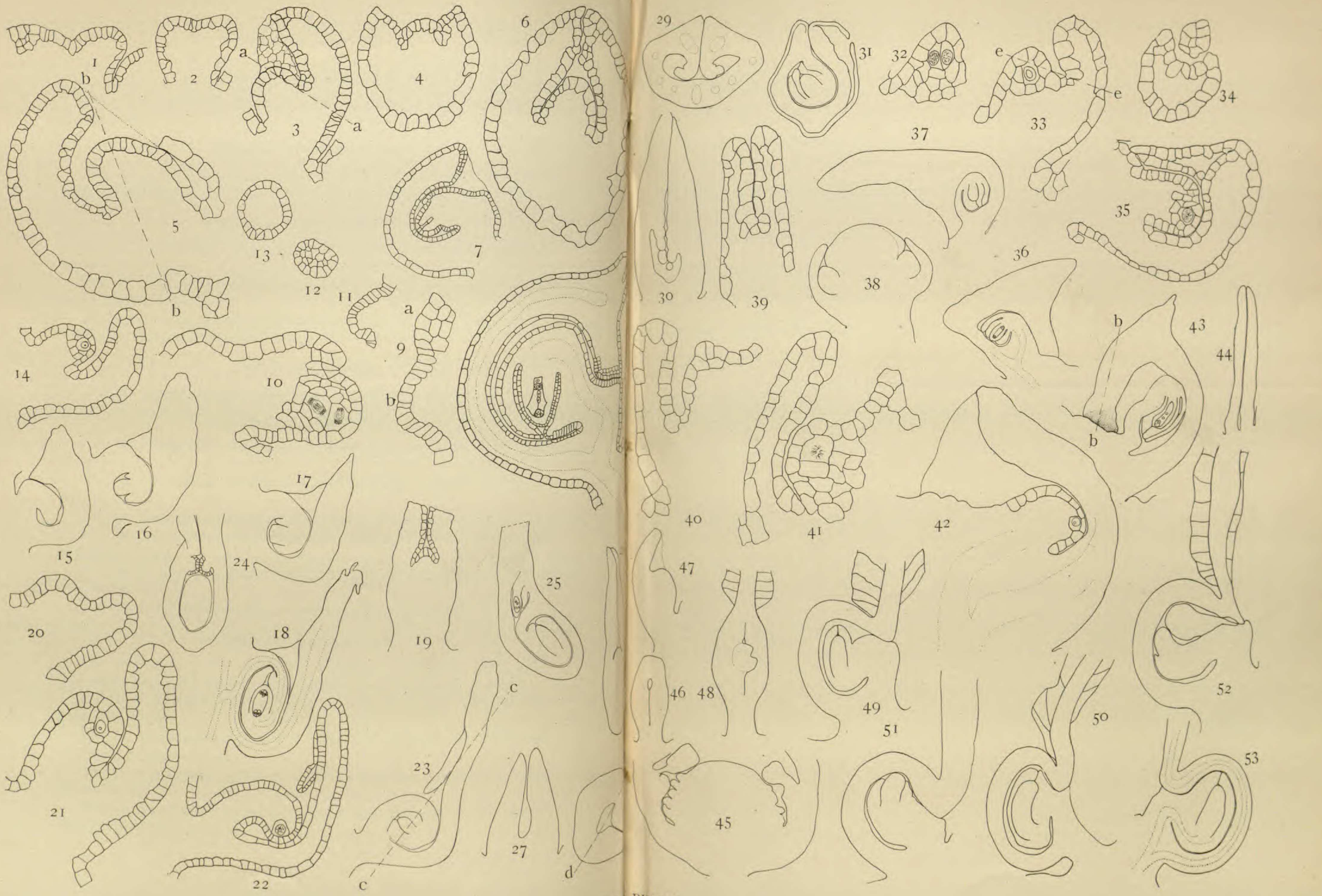
FIG. 38. Longitudinal section of a young flower showing the young pistil. The dotted line shows the level of the surface of the receptacle. × 155.

FIG. 39. Longitudinal ventral section of a pistil slightly older than the preceding. × 555.

FIG. 40. Longitudinal section of a young pistil in which the ovule is just beginning to appear. × 545.

FIG. 41. Longitudinal section of a pistil showing the archesporium. The section is slightly to one side of the median plane. × 555.

FIG. 42. Longitudinal section of a pistil at a further stage of development than the preceding. × 400.



BESS PISTILS